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# TRASH COLLECTING SYSTEMS AT COTTON GINS

By E. A. Harrell and V. P. Moore 1/

The use of machinery for harvesting cotton has very much increased the trash handling problems at gins. Gin machinery needed to process the trashier cottons has also further complicated the trash handling problem. During the ginning process trash is collected from each cleaner (both seed cotton and lint cleaners) and conveyed to a collection and disposal point by air. If collection precautions are not taken, the trash will be released into the atmosphere. The discharge of waste materials to the atmosphere generally results in only a local problem. However, the number of establishments and the gradual urban encroachment into the areas of ginning is great enough to warrant suitable collecting units and disposal methods.

The large particles of trash are not difficult to collect. In all probability particles 100 microns and larger will remain on the ginning premises, whereas particles smaller than 100 microns will be carried beyond the premises into the surrounding communities by a 10-mile-per-hour wind.

Work was begun on trash collection problems at cotton gins in the fall of 1955 at the U. S. Cotton Ginning Research Laboratory. Part of the information resulting from this study has been published. 2/ Much is yet to be learned about the design of trash collecting systems. However, the following information should be helpful in dealing with this growing problem.

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1/ Agricultural Engineer and Cotton Technologist, respectively, Agricultural Engineering Research Division, Agricultural Research Service, U. S. Department of Agriculture at Stoneville Cotton Ginning Research Laboratory, Stoneville, Mississippi.

2/ What We Know About Air Pollution, by Texas Cotton Ginners' Association, Dallas, Texas.

The most widely used devices for collecting trash in gins are the cyclones. They are used extensively because they are effective, cheap, and require little maintenance. Cyclones are essentially cylindrical in shape, with a long, conical hopper bottom. The trash-laden air enters tangentially near the top and spirals down toward a central cylinder through which the dust-free air escapes. Centrifugal force caused by the whirling action of the trash and air causes the trash to be forced outwardly through the air and into the conical hopper below, while the central core of dust-free air passes up and out through the central cylinder.

Cyclones are used satisfactorily for trash collection on air lines supplied by high-pressure fans. These fans are commonly used in gins for conveying purposes and the impeller blades are made of steel plate. (Fig. 1.)

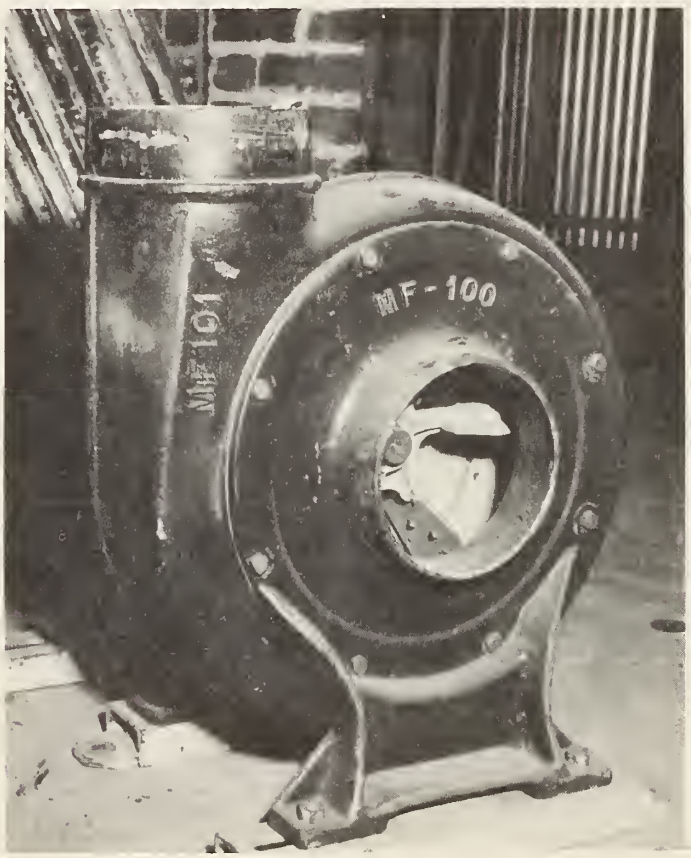



Figure 1. Typical centrifugal type fan used in cotton gins.

Cyclones are not used on air lines supplied by low-pressure volume fans of the axial type. (Fig. 2.) These fans in use at gins are not designed to develop pressures required for efficient cyclone operation. Instead of cyclones, screen cages commonly called "lint fly catchers" are used on these low-pressure lines.

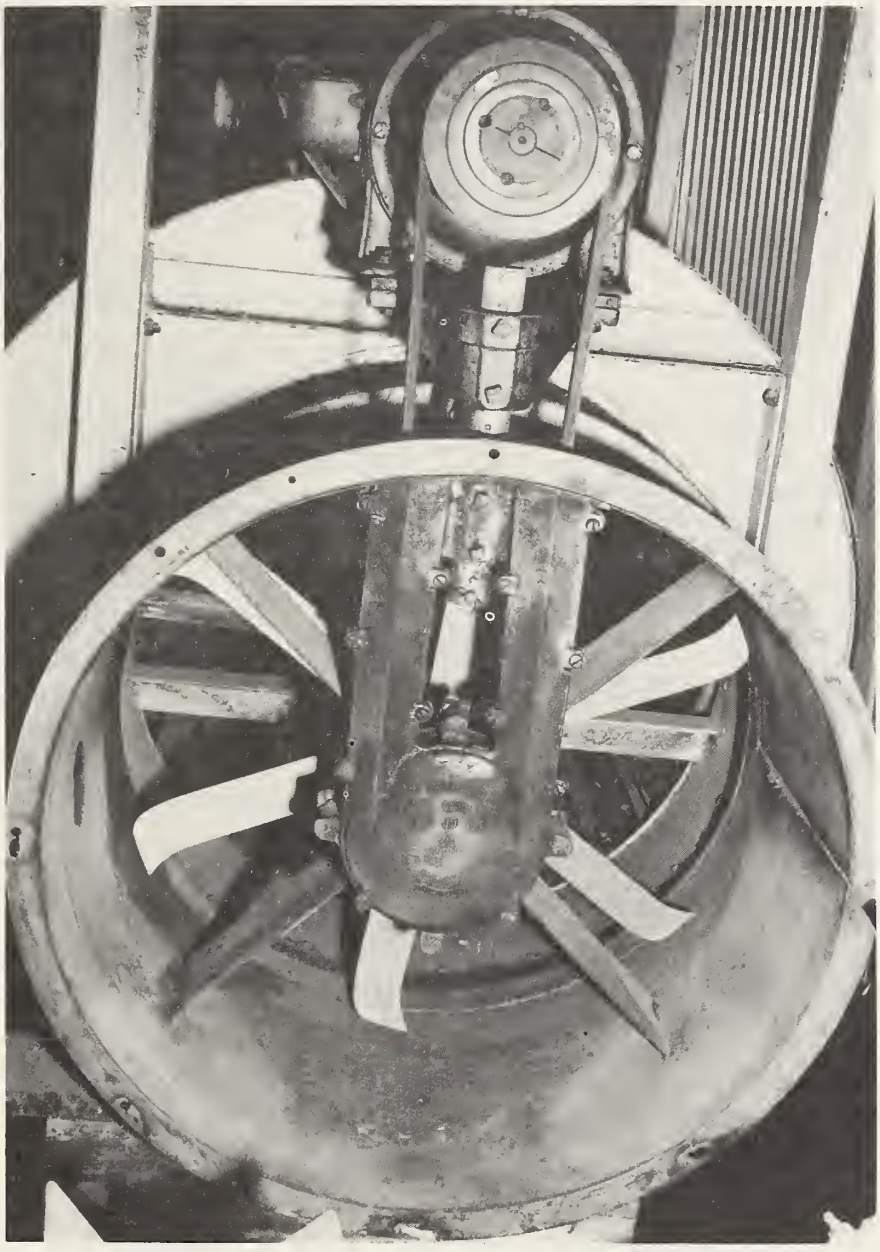


Figure 2. Low-pressure axial type fan.

For the purpose of research certain commercial machines were used in these investigations.[3/]

## Cyclones

Cyclones in use at cotton gins today may be classified generally as large-diameter and small-diameter units. Each has its advantages and both will do a satisfactory job of collecting the dust, if engineered properly. A comparison of the trash collecting efficiencies of the large- and small-diamter units is shown in table 1.

Table 1. A comparison of cyclone efficiencies on small trash after the large particles had been removed.

| Cyclone | Air volume[1/] | Trash volume[2/] | Efficiency |
|---|---|---|---|
| | c.f.m. | g./min. | pct. |
| Large-diameter, low-pressure trash exit opened | 6,204 | 25.789 | 79.73 |
| Large-diameter, low-pressure trash exit closed | 6,061 | 29.127 | 63.03 |
| Small-diameter, high-pressure trash exit opened | 5,917 | 20.241 | 83.86 |
| Small-diameter, high-pressure trash exit closed | 5,767 | 17.614 | 84.34 |

1/ Air volume range on small-diameter cyclones 4,580 to 6,771 c.f.m. Two cyclones used parallel.

Air volume range on large-diameter cyclone 4,965 to 6,771 c.f.m. One cyclone used.

2/ Trash volume range - 4.636 g./min. to 55.033 g./min.
Trash volume range - 6.847 g./min. to 76.268 g./min.

3/ Mention of companies or products is not to be construed as an endorsement of these firms or products by the U. S. Department of Agriculture.

One of the most important factors in engineering a cyclone installation is to accurately determine the air volume. When it is not possible to actively measure the air volumes, they may be estimated. Such estimating may be made by using tables 2 and 3 as a guide.

Table 2. Pipe diameters, areas in square inches and volumes in c.f.m. at mean velocity of 4,500 f.p.m.

| Pipe diameter | Area | Volume |
|---|---|---|
| in. | sq. in. | c.f.m. |
| 5 | 19.64 | 612 |
| 6 | 28.27 | 882 |
| 7 | 38.49 | 1202 |
| 8 | 50.27 | 1571 |
| 9 | 63.62 | 1989 |
| 10 | 78.54 | 2453 |
| 11 | 95.03 | 2970 |
| 12 | 113.10 | 3533 |
| 13 | 132.73 | 4149 |
| 14 | 153.94 | 4811 |
| 15 | 176.71 | 5522 |
| 16 | 201.06 | 6282 |
| 18 | 254.47 | 7952 |
| 20 | 314.16 | 9819 |

Table 3. Estimated air volume from various sources.

| Fan service | Estimated air volumes (c.f.m.) |
|---|---|
| Air from unloading fan | 1250 c.f.m. per gin stand |
| Air from driers (or drier-cleaner combinations) | 6000 c.f.m. per drier |
| Air from feeder-driers | 1200 c.f.m. per gin stand |
| Air from 10 in. trash line | 2200 1/ |
| Air from 11 in. trash line | 2600 1/ |
| Air from 12 in. trash line | 3100 1/ |
| Air from 13 in. trash line | 3700 1/ |
| Air from 14 in. trash line | 4300 1/ |

1/ Based on 4,000 f.p.m. velocity in pipe.

## Large-Diameter Cyclone

After determining the air volume in cubic feet per minute (c.f.m.), the size cyclone can be determined by the use of the following formulas and tables.

### Formulas for Determining Large-Diameter Cyclone Sizes

(1) Vent stack diameter commonly equals one-half nominal (outside) cyclone diameter. When given the size of the cyclone and the desired velocity of air through its vent stack, then

(2) Air volume entering cyclone (c.f.m.) equals

$$\frac{\text{vent air velocity (f.p.m.)} \times \text{vent diameter}^2 \text{(ft.}^2\text{)}}{1.273}$$

When given the size of the cyclone and the volume of air which is to enter the cyclone, then

(3) Vent air velocity (f.p.m.) equals

$$\frac{1.273 \times \text{air volume entering cyclone (c.f.m.)}}{\text{vent diameter}^2 \text{ (ft.}^2\text{)}}$$

When given the volume of air which is to enter the cyclone and the desired velocity of air in the vent stack, then

(4) Vent diameter (ft.) = $1.128 \sqrt{\frac{\text{air volume entering cyclone (c.f.m.)}}{\text{vent air velocity (c.f.m.)}}}$

(5) Cyclone diameter (ft.) = vent diameter (ft.) x 2

A velocity of 600 f.p.m. in the vent stack is commonly used for gin trash. For example, a cyclone to handle 13,000 c.f.m. (cubic feet per minute) with a vent velocity of 600 f.p.m. (feet per minute) would be 10 feet and 6 inches in diameter. The dimensions of this and other large-diameter cyclones can be obtained from table 4. The dimensions for large-diameter cyclones are shown in figure 3.

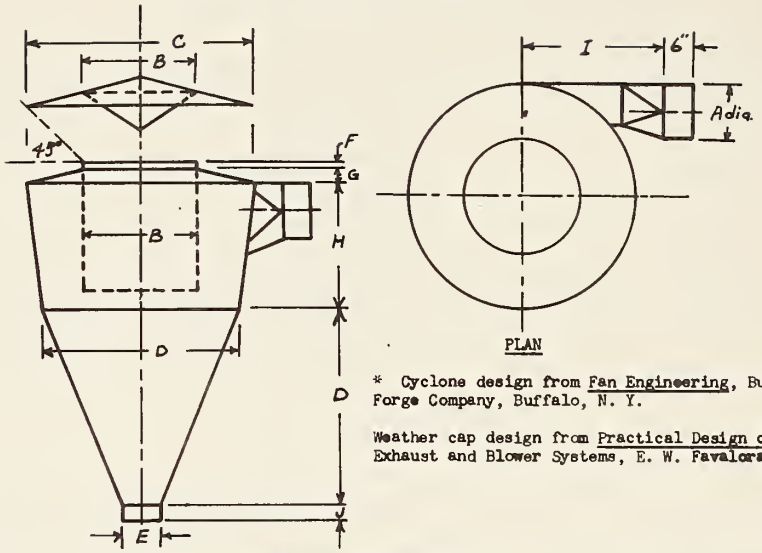
## Small-Diameter Cyclones

For new installations the ginner will in all probability profit by selecting small-diameter cyclones. They are more efficient, cheaper, easier to fabricate and install, and only one air line enters a cyclone or group of cyclones. However, the small-diameter cyclones do require slightly more horsepower (Fig. 4.) Fans used on these installations must be able to overcome a pressure drop of 4 to 5 inches of water.

Table 4. Large-diameter cyclone selection table based on a vent velocity of 600 f.p.m.

| Air volume | Vent diameter | Cyclone diameter |
|---|---|---|
| c.f.m. | ft. - in. | ft. - in. |
| 3,000 | 2 - 6 | 5 - 0 |
| 4,000 | 2 - 11 | 5 - 10 |
| 5,000 | 3 - 3 | 6 - 6 |
| 6,000 | 3 - 7 | 7 - 2 |
| 7,000 | 3 - 10 | 7 - 8 |
| 8,000 | 4 - 1 | 8 - 2 |
| 9,000 | 4 - 4 | 8 - 8 |
| 10,000 | 4 - 7 | 9 - 2 |
| 11,000 | 4 - 10 | 9 - 8 |
| 12,000 | 5 - 1 | 10 - 2 |
| 13,000 | 5 - 3 | 10 - 6 |
| 14,000 | 5 - 5 | 10 - 10 |
| 15,000 | 5 - 8 | 11 - 4 |
| 16,000 | 5 - 10 | 11 - 8 |
| 17,000 | 6 - 0 | 12 - 0 |
| 18,000 | 6 - 2 | 12 - 4 |

DIMENSIONS OF COMMERCIAL TYPE CYCLONE *




* Cyclone design from Fan Engineering, Buffalo Forge Company, Buffalo, N. Y.

Weather cap design from Practical Design of Exhaust and Blower Systems, E. W. Favalora

Dimensions in Inches

| A | B | C | D | E | F | G | H | I | J | Wgt. |
|---|---|---|---|---|---|---|---|---|---|---|
| 8 | 16 | 32 | 28 | 7 | 3/4 | 2 | 18 | 20 | 3 | 125 |
| 10 | 20 | 40 | 35 | 8 | 3/4 | 2-1/2 | 22-1/2 | 25 | 3 | 150 |
| 12 | 24 | 48 | 42 | 8 | 3/4 | 3 | 27 | 30 | 4 | 200 |
| 14 | 28 | 56 | 49 | 8 | 7/8 | 3-1/2 | 31-1/2 | 35 | 4 | 350 |
| 16 | 32 | 64 | 56 | 8 | 7/8 | 4 | 36 | 40 | 4 | 450 |
| 18 | 36 | 72 | 63 | 9 | 7/8 | 4-1/2 | 40-1/2 | 45 | 5 | 565 |
| 20 | 40 | 80 | 70 | 10 | 1 | 5 | 45 | 50 | 5 | 695 |
| 22 | 44 | 88 | 77 | 11 | 1 | 5-1/2 | 49-1/2 | 55 | 6 | 835 |
| 24 | 48 | 96 | 84 | 12 | 1 | 6 | 54 | 60 | 6 | 990 |
| 26 | 52 | 104 | 91 | 13 | 1 | 6-1/2 | 58-1/2 | 65 | 6 | 1150 |
| 28 | 56 | 112 | 98 | 14 | 1 | 7 | 63 | 70 | 6 | 1330 |
| 30 | 60 | 120 | 105 | 15 | 1-1/8 | 7-1/2 | 67-1/2 | 75 | 6 | 1800 |
| 32 | 64 | 128 | 112 | 16 | 1-1/8 | 8 | 72 | 80 | 7 | 2050 |
| 34 | 68 | 136 | 119 | 17 | 1-1/8 | 8-1/2 | 76-1/2 | 85 | 7 | 2310 |
| 36 | 72 | 144 | 126 | 18 | 1-1/8 | 9 | 81 | 90 | 7 | 2580 |
| 38 | 76 | 152 | 133 | 19 | 1-1/4 | 9-1/2 | 85-1/2 | 95 | 7 | 2880 |
| 40 | 80 | 160 | 140 | 20 | 1-1/4 | 10 | 90 | 100 | 8 | 3190 |
| 42 | 84 | 168 | 147 | 21 | 1-1/4 | 10-1/2 | 94-1/2 | 105 | 8 | 3650 |
| 44 | 88 | 176 | 154 | 22 | 1-1/2 | 11 | 99 | 110 | 8 | 3880 |
| 46 | 92 | 184 | 161 | 23 | 1-1/2 | 11-1/2 | 103-1/2 | 115 | 8 | 4240 |
| 48 | 96 | 192 | 168 | 24 | 1-1/2 | 12 | 108 | 120 | 8 | 4610 |

Sizes 8 to 28 inc. of No. 18 Ga. Galv. Iron
Sizes 30 to 48 inc. of No. 16 Ga. Galv. Iron

Figure 3. Dimensions for large-diameter cyclones.

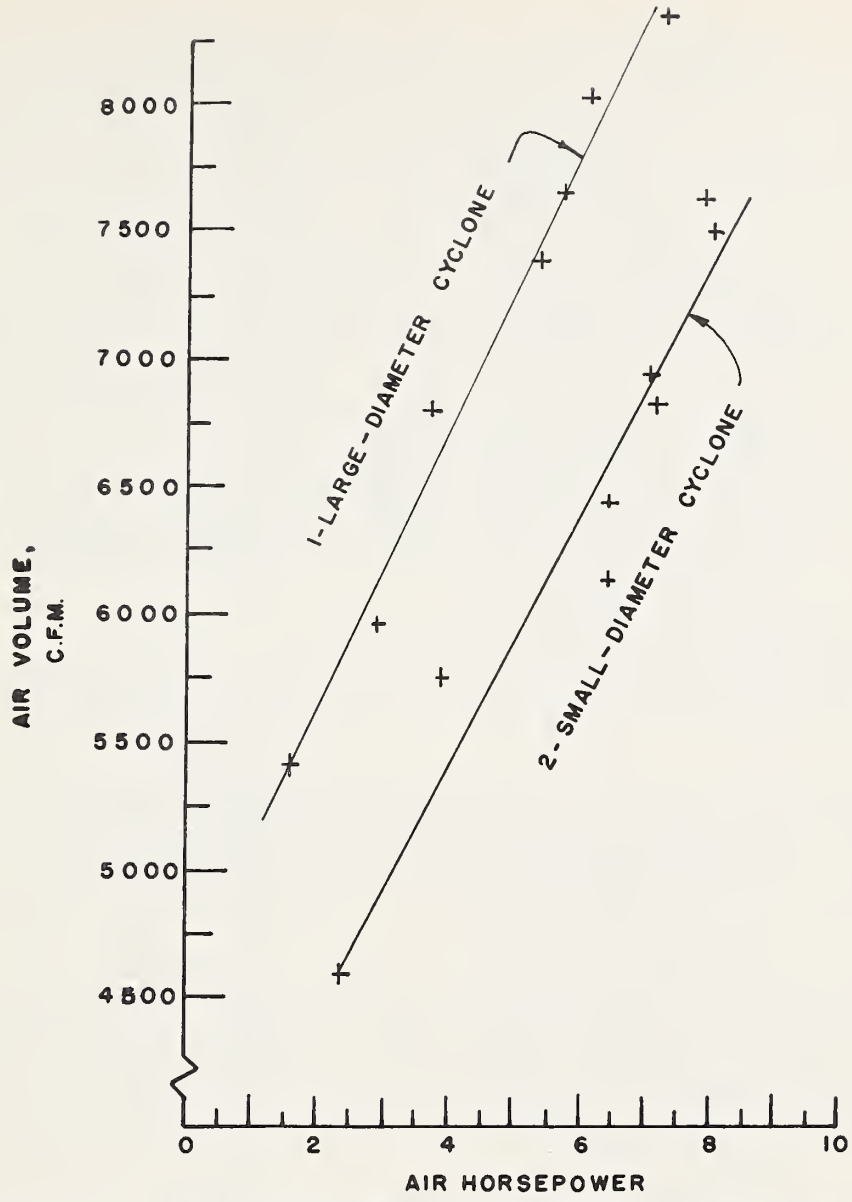



Figure 4. Power requirements: - large-diameter vs small-diameter cyclones.

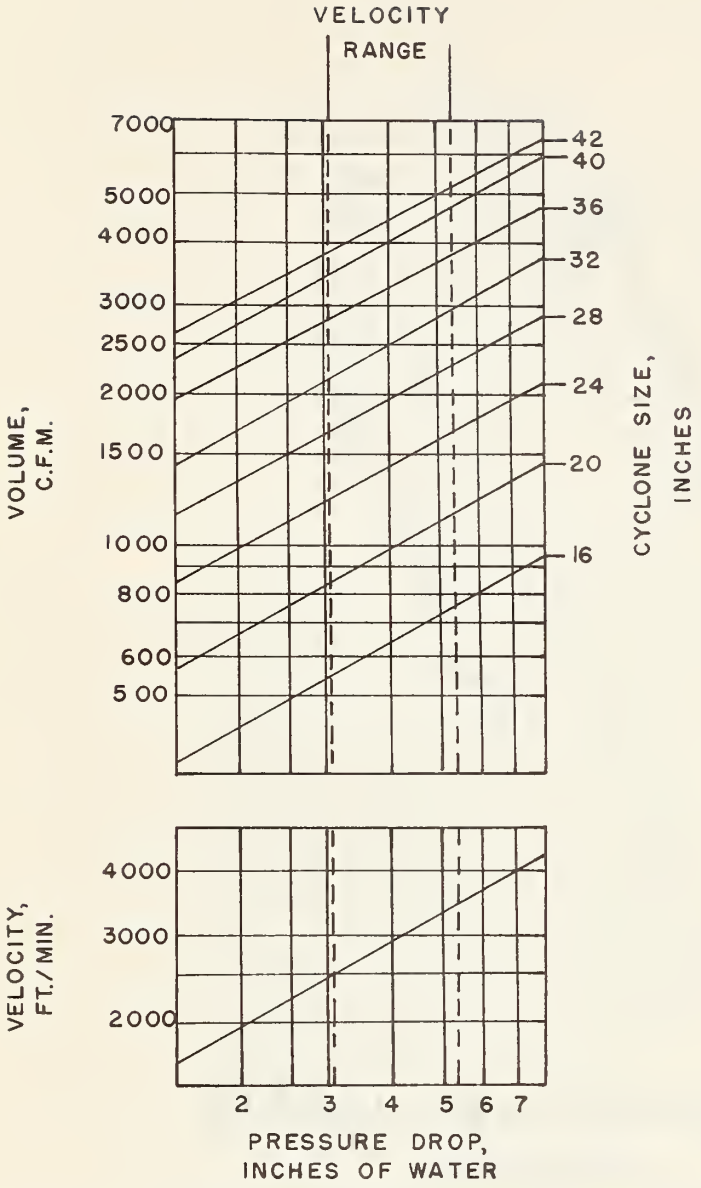



Figure 5. High efficiency cyclone selection chart.

Selection of the proper size small-diameter cyclone is done in much the same manner as with the large-diameter units. Air volume is very important and can also be determined for these cyclones from tables 1 and 2 or measured. It is recommended that the velocity entering the cyclone be kept to a minimum of 3,000 f.p.m. and the volume be not over 4,590 c.f.m. The cyclone may be designed for operation at a higher entrance velocity provided the system can withstand a greater pressure drop. (Fig. 5.)

Cyclone selection should be made from this chart between the heavy dotted lines to provide a good compromise of collecting efficiency to horsepower load or pressure drop. These limits are within those obtained by centrifugal gin fans and correspond to the recommended inlet volocities of 3,000 f.p.m. The higher the inlet velocity, the higher will be the separating efficiency and also the greater the horsepower required to operate the units. For the best results in collecting dust at gins a unit has been designed with a pressure drop of 4 to 5 inches, which is within the limits of most centrifugal fans in use at gin plants.

After determining the air volume, the proper size of small-diameter cyclone can be obtained from figure 5. Should the volume be more than 3,000 c.f.m., two or more cyclones may be used in parallel. Do not attempt to increase the collection efficiency by installing a pair of identical cyclones in series. The collection efficiency of two identical units is no greater than that of one. The number and size of cyclones to use on an installation can be determined from table 5. It is recommended that the size be selected above the horizontal lines in this table. For example, a volume of 2,664 c.f.m. requires one 32-inch-diameter cyclone, while an air volume of 6,000 c.f.m. would require two 34-inch-diameter units mounted in parallel, and a volume of 9,000 c.f.m. mounted in parallel would require four 29.4-inch-diameter units.

An inlet transition for double-mounted, small-diameter cyclones is shown in figure 6. For installations requiring quadruple mounts, refer to figure 7. When selecting transitions for multiple-mounted cyclones, avoid sharp edges whenever possible. A rounded edge will shed gin trash whereas a sharp edge tends to cause trash to lodge.

The small-diameter cyclone and lint fly catcher installations at the U. S. Cotton Ginning Research Laboratory, Stoneville, are shown in figure 8. Small-diameter cyclones work quite satisfactorily with an incinerator. Such an installation is shown in figure 9.

Space and height limitations may also be a factor in choosing a multiple mount. A cyclone 4 feet in diameter will be a minimum of 17 feet high, whereas a 2 foot-diameter cyclone will be only 9 feet high. A good rule of thumb in selecting small-diameter cyclones is to keep the diameter less than 34 inches.

A straight run of pipe should enter the cyclone to reduce turbulence and provide the best conditions for separation. The straight run should be a minimum of 7 to 10 feet. In the case of multiple mounts, unless the inlet pipe is straight, one of the cyclones may be getting more trash-laden air than it was designed to handle and therefore would not function correctly.

## Lint Fly Catchers

A unique wire cage has been designed for collecting lint fly from condenser exhausts. It is nothing more than a cylindrical unit made from 14- to 18-gauge screen wire. To operate satisfactorily the cage must be kept dry and sized properly. Moisture on the screen area will prevent the units from operating properly. Louvers designed by the USDA Ginning Laboratory may be attached to the lint catcher and will, except under extreme conditions, prevent moisture from accumulating on the screen. To insure best operation under all conditions, lint fly catchers would be installed in a house where they cannot get wet. In this case the louvers are not necessary.

Table 5. Dimension proportions and arrangement for a single, double, or quadruple installation.

| Air entering cyclone | Cyclone dimensions: Single Dia. Dc | Height Lc / Zc | Inlet Bc x Hc | Double Dia. Dc | Height Lc / Zc | Inlet Bc x Hc | Quadruple Dia. Dc | Height Lc / Hc | Inlet Bc x Hc |
|---|---|---|---|---|---|---|---|---|---|
| c.f.m. | in. | ft. | in. | in. | ft. | in. | in. | ft. | in. |
| 666 | 16.0 | 5.4 | 4.0 x 8.0 | | | | | | |
| 1,042 | 20.0 | 6.8 | 5.0 x 10.0 | | | | | | |
| 1,500 | 24.0 | 8.0 | 6.0 x 12.0 | | | | | | |
| 2,042 | 28.0 | 9.4 | 7.0 x 14.0 | | | | | | |
| 2,664 | 32.0 | 10.8 | 8.0 x 16.0 | | | | | | |
| 3,000 | 34.0 | 11.3 | 8.5 x 17.0 | 24.0 | 8.0 | 6.0 x 12.0 | 17.0 | 5.7 | 4.25 x 8.5 |
| 4,000 | 39.2 | 13.1 | 9.8 x 19.6 | 27.6 | 9.2 | 6.9 x 13.8 | 19.6 | 6.5 | 4.90 x 9.8 |
| 5,000 | 44.0 | 14.7 | 11.0 x 22.0 | 31.2 | 10.4 | 7.8 x 15.6 | 22.0 | 7.3 | 5.50 x 11.0 |
| 6,000 | 48.0 | 16.0 | 12.0 x 24.0 | 34.0 | 11.3 | 8.5 x 17.0 | 24.0 | 8.0 | 6.00 x 12.0 |
| 7,000 | 52.0 | 17.3 | 13.0 x 26.0 | 36.8 | 12.3 | 9.2 x 18.4 | 26.0 | 8.7 | 6.50 x 13.0 |
| 8,000 | 56.0 | 18.7 | 14.0 x 28.0 | 39.6 | 13.2 | 9.9 x 19.8 | 28.0 | 9.3 | 7.00 x 14.0 |
| 9,000 | 58.8 | 19.6 | 14.7 x 29.4 | 41.6 | 13.9 | 10.4 x 20.8 | 29.4 | 9.8 | 7.40 x 14.7 |
| 10,000 | 62.0 | 20.7 | 15.5 x 31.0 | 43.6 | 14.5 | 10.9 x 21.8 | 31.0 | 10.3 | 7.75 x 15.5 |
| 11,000 | 64.8 | 21.6 | 16.2 x 32.4 | 45.6 | 15.2 | 11.4 x 22.8 | 32.4 | 10.8 | 8.10 x 16.2 |
| 12,000 | 68.0 | 22.7 | 17.0 x 34.0 | 48.0 | 16.0 | 12.0 x 24.0 | 34.0 | 11.3 | 8.50 x 17.0 |

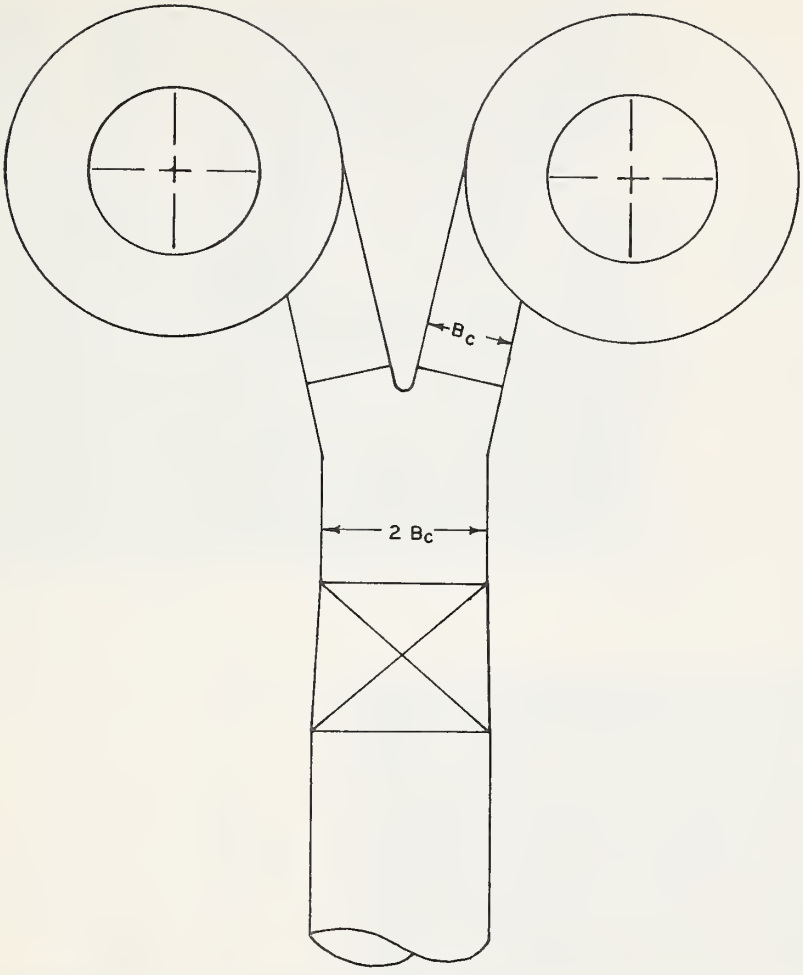



Figure 6. Inlet transition designed for double-mounted small-diameter cyclones.

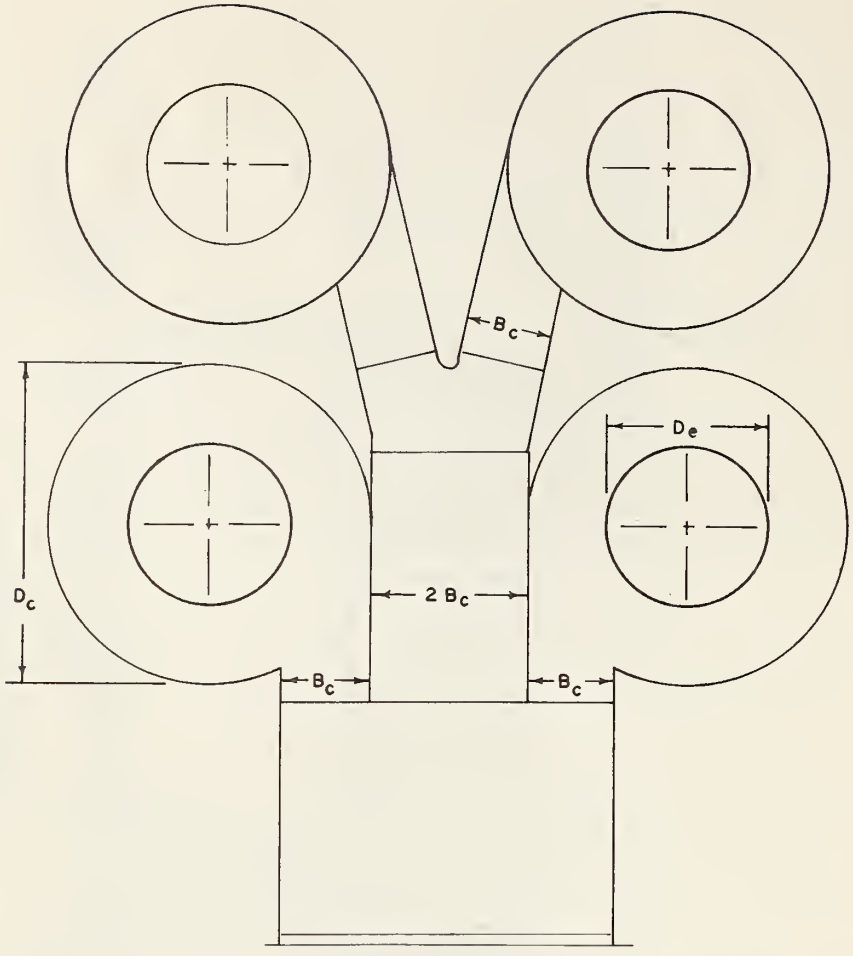



Figure 7. Inlet transition designed for quadruple-mounted small-diameter cyclones.

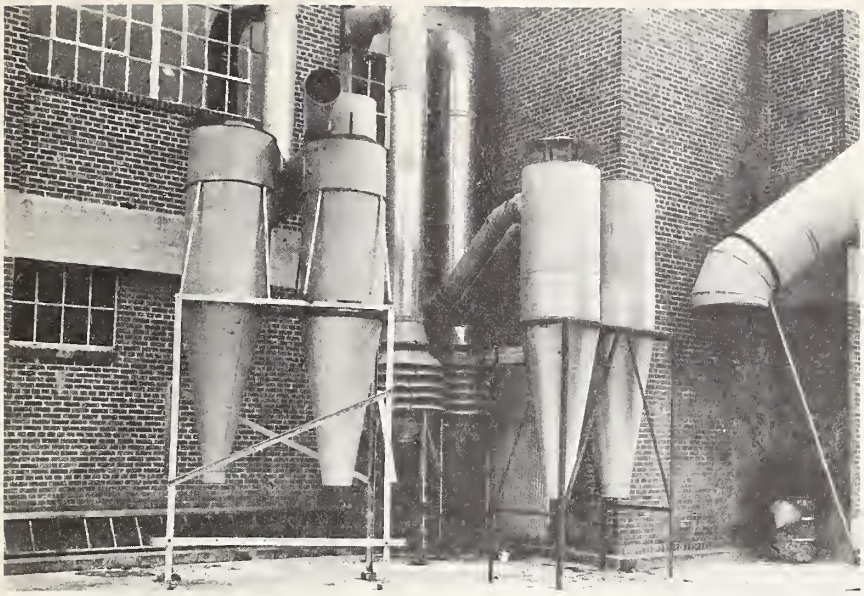


Figure 8. Small-diameter cyclone and lint fly catcher installation.

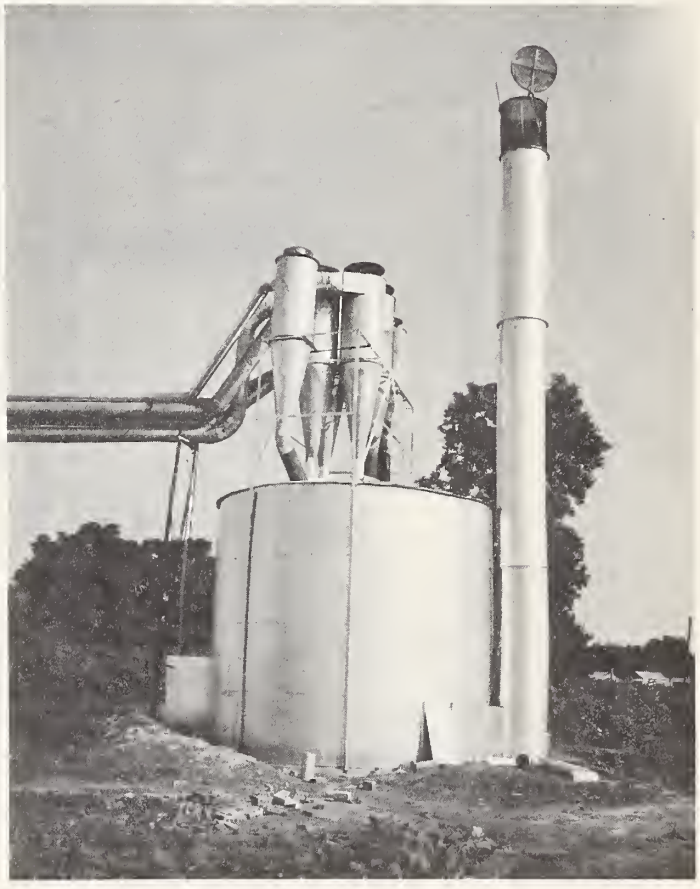


Figure 9. Small-diameter cyclones installed over an incinerator.

Any moisture will cause the screen wire to hair over and create a back pressure on the condenser exhaust and, if allowed to continue, the pressure will eventually build up and cause chokages in the gin machinery.

Lint fly catchers attached to condenser exhaust are protected from the weather by being placed under a shed or equipped with louvers. The outlets connected to the suction of a fan require very little attention for satisfactory operation. (Fig. 10.) Units requiring a sack on the bottom for collecting lint fly require frequent attention. The bag must be emptied regularly and the inside of the unit must be cleaned occasionally. Usually emptying the bag two or three times a day is sufficient for satisfactory operation.

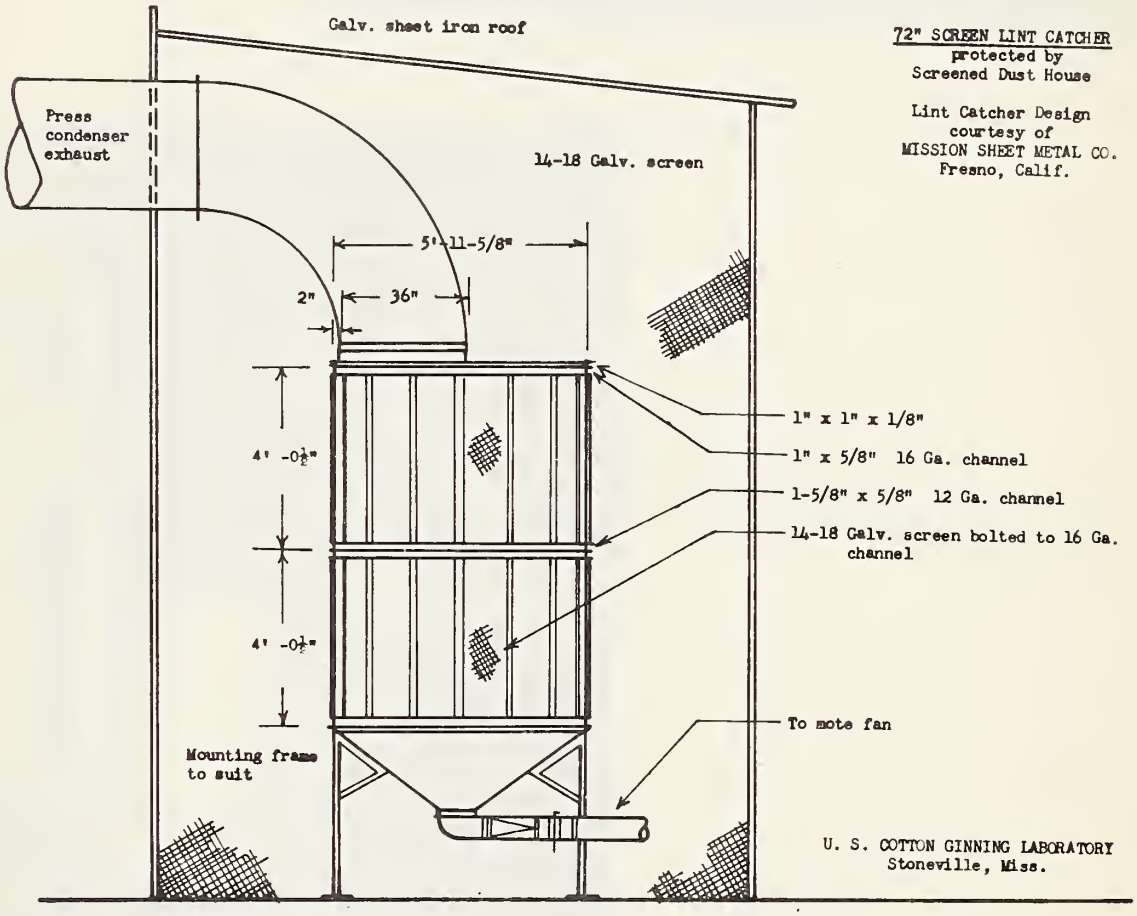



Figure 10. Lint fly catcher installation.

When lint fly catchers are installed in a shed, precautions must be taken to provide adequate ventilation from the shed. Pressure will build up on the units if the air cannot escape fast enough from the shed. The open space between the units and any obstacle should not be less than 18 inches.

The size lint catcher to use depends upon air volumes and pressures in the pipe. To insure satisfactory operation, the air volume should be measured accurately if at all possible. When measurements cannot be made, the manufacturer of the equipment should be consulted for the correct volume of air. A handy rule to follow in estimating the air volume from condensers connected to gin stand lint flues is to allow a volume of 1,300 c.f.m. per hundred gin saws in the battery. This rule may not be absolutely accurate on the second condenser of tandem installations or installations where air is induced into the system. However, for most gin work the rule is sufficiently accurate to give satisfactory results.

The proper size lint catcher for a given air volume is shown in table 6. These data are based on there being an axial fan installed between the condenser and lint fly catcher. On installations where a catcher is needed on a condenser that does not have a fan, a unit 72 inches in diameter by 96 inches long should be used. (Fig. 10.)

Table 6. Selection table for lint fly catchers.

| Air volume | Diameter | Length |
|---|---|---|
| c.f.m. | in. | in. |
| 3,000 | 36 | 48 |
| 4,000 | 42 | 48 |
| 5,000 | 42 | 60 |
| 6,000 | 42 | 72 |
| 7,000 | 45 | 72 |
| 8,000 | 48 | 72 |
| 9,000 | 48 | 84 |
| 10,000 | 50 | 84 |
| 11,000 | 53 | 84 |

A diagram of a 36-inch lint fly catcher without louvers is illustrated in figure 11 and a unit with louvers installed is shown in figure 12.

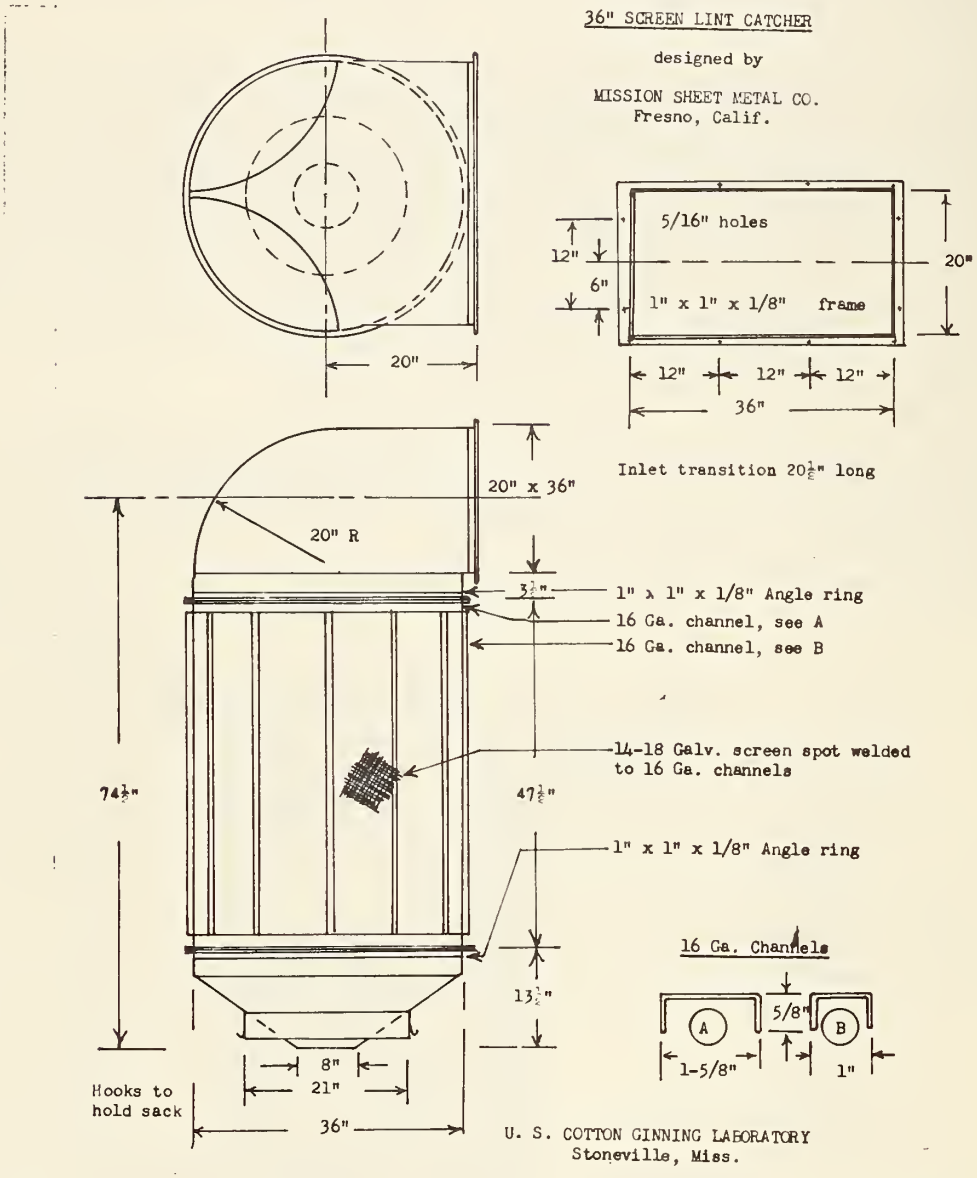



Figure 11. Lint fly catcher installation without louvers.

U. S. COTTON GINNING LABORATORY
Stoneville, Miss.

Sheet Metal Louvers Added by
Stoneville Laboratory for Use
in Rainy Areas

36" SCREEN LINT CATCHER

designed by

MISSION SHEET METAL CO.
Fresno, Calif.

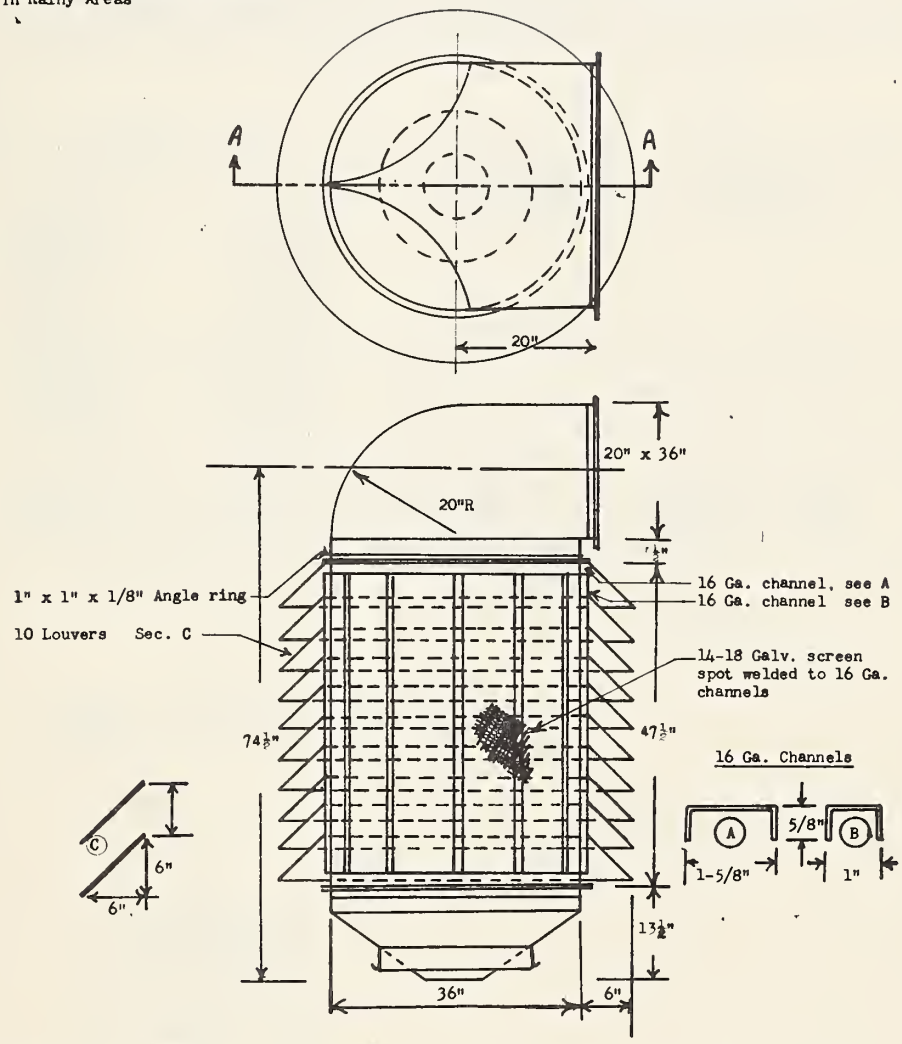



Figure 12. Lint fly catcher installation with louvers.

A system for collecting and disposing gin trash is shown in figure 13. There are numerous equally good variations of units for collecting trash from the gin and conveying it to incinerators or large trash hopper for disposal. When lint fly catchers are attached to an air line, a slide valve should be installed under the unit as illustrated to regulate air flow.

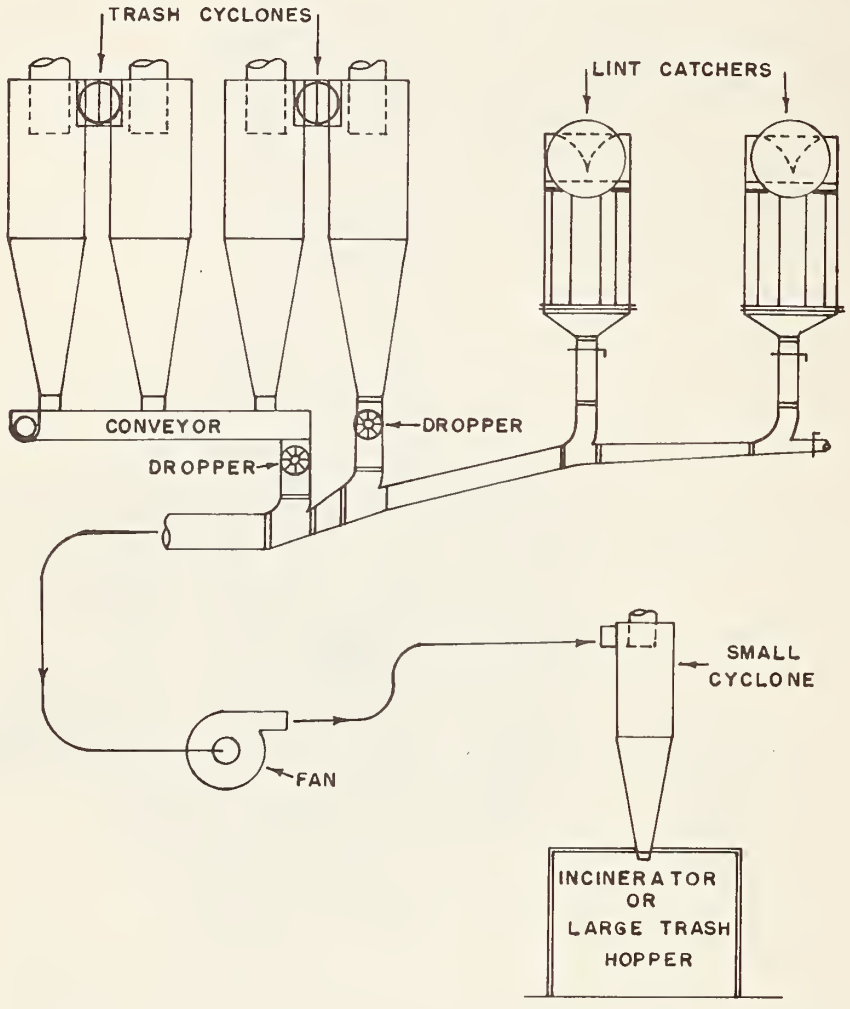



Figure 13. Gin trash collection and disposal system.

## Settling Chamber

The collection of cotton gin trash by cyclones and lint fly catchers is the most satisfactory method to use. However, some gins use dust houses or settling chambers with some degree of success. They are used most in areas where space is no problem and the dangers of air pollution are not so great.

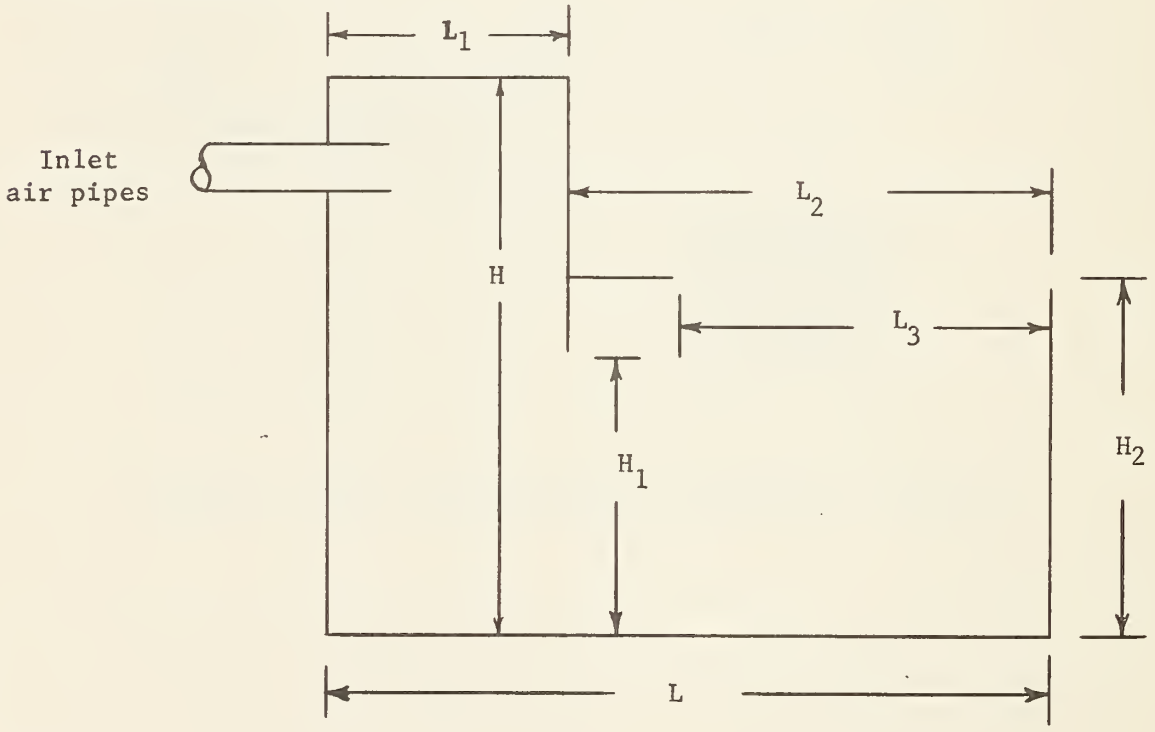
Settling chambers must be of sufficient size and of such design as to prevent small trash particles from being carried into the atmosphere by air currents. Velocities of air at the outlet should be less than 75 f.p.m. The correct dimensions for handling different volumes of incoming air are shown in table 7.

Much is yet to be learned about trash collection and the operation of cyclones and lint collectors. Careful attention must be given to details, and quite often some adjustments made in the system to make the units operate properly. However, the various systems described will work if properly engineered. At best, the collection of trash is difficult and expensive. Numerous devices are tried from time to time and some of them are working satisfactorily. In cases where trash collection equipment being used is satisfactory, regardless of the design or type, there is no reason to change.

Table 7. Cotton gin dust settling chamber design and dimensions.

| Air entering settling chamber | Settling chamber dimensions | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | H | $H_1$ | $H_2$ | L | $L_1$ | $L_2$ | $L_3$ | Width |
| c.f.m. | ft. | ft. | ft. | ft. | ft. | ft. | ft. | ft. |
| 10,000 | 12 | 6 | 9 | 18 | 6 | 12 | 7-1/2 | 18 |
| 15,000 | 15-1/2 | 7-3/4 | 9-3/4 | 19-1/2 | 6-1/2 | 13 | 10-1/4 | 19-1/2 |
| 20,000 | 18 | 9 | 11-1/4 | 22-1/2 | 7-1/2 | 15 | 12 | 22-1/2 |
| 25,000 | 20 | 10 | 12-3/4 | 25-1/2 | 8-1/2 | 17 | 13-1/4 | 25-1/2 |
| 30,000 | 22 | 11 | 13-7/8 | 27-3/4 | 9-1/4 | 18-1/2 | 14-3/4 | 27-3/4 |
| 35,000 | 23-1/2 | 11-3/4 | 15 | 30 | 10 | 20 | 15-1/2 | 30 |
| 40,000 | 25-1/2 | 12-3/4 | 15-3/4 | 31-1/2 | 10-1/2 | 21 | 17 | 31-1/2 |
| 45,000 | 27-1/2 | 13-3/4 | 16-1/2 | 33-1/2 | 11 | 22 | 18-1/4 | 33 |
| 50,000 | 28 | 14 | 18 | 36 | 12 | 24 | 18-1/2 | 36 |

Air inlet pipes should be kept well above lower edge of baffle. Dimension $H_1$ should be large enough to insure that the air velocity into the outer chamber will be less than 100 f.p.m. Dimension $L_3$ should be large enough to insure that the outlet air velocity will be less than 75 f.p.m.




Growth Through Agricultural Progress